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The attainment of peak bone mass during the premenopausal years is critical in preventing osteoporosis later in life. The purpose of this study was to determine if peak bone mass can be improved after age 20, the age near which peak bone mass is usually reached, and to compare the effects of region specific resistance exercise with aerobic exercise. Forty three volunteers completed six months of the protocol. Thirty individuals completed twelve months with fifteen in each group. Bone density was shown to significantly increase in the spine, femoral neck and radius by 12 months in both groups. The resistance exercise group had significantly higher densities at the femoral neck and mid-radius at 12 months.

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PI - Signature Date
25 June 1996

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Introduction

Postmenopausal osteoporosis is a growing health concern in the United States ultimately generating over $10 billion annually in health care costs. Development of osteoporosis in later life is known to reflect lack of bone health in early life. Peak bone mass is achieved between ages 18 and 35 and becomes the reserve upon which further aging and menopause will draw over the remainder of an individual's life.

Prevention of postmenopausal osteoporosis is recognized to be dependent on calcium intake, physical activity and genetics, as these factors determine the maximum peak bone mass in young women. Skeletal effects of exercise have been the subject of extensive recent literature reviews[1-3]. Cross-sectional studies have suggested higher bone mass developing in regions of specific bone loading exercises. However, these studies were flawed by self selection and many inconsistencies which have rendered the overall results inconclusive. Prospective longitudinal studies have shown benefit of vigorous aerobic and resistance exercises, especially in the loaded areas. These benefits appear to be true for both premenopausal and postmenopausal women. These studies were flawed, however, by inadequate randomization. One cross-sectional study of premenopausal women showed weight training to be more effective than aerobic(4). However, four well designed prospective studies on pre- and postmenopausal women have shown varying results which include an increase[5], minimal increase[6], no

change[7], and a decrease[8] of bone mass in the loaded regions.

In this study 82 premenopausal women ages 18-40 were enrolled in a one year period in either a resistance-exercise (Nautilus) group or an aerobic group.

Individuals enrolled in the Nautilus group performed exercises specifically designed to strengthen the lower back, abdomen, hips and arms in three 30-minute sessions per week. All individuals in the study completed a questionnaire on calcium intake and were given calcium supplements or were asked to increase dietary calcium intake to fulfill current recommendations for calcium intake of 1000 mg/day in premenopausal women. Bone density determinations were done on entry into the study and at six months and at one year for the lumbar spine, hip and radius which were the areas most likely to be affected by osteoporotic fractures.

Body

Eighty-two premenopausal women ages 18-40 were initially enrolled in the study and calcium intake and baseline laboratory data collected. The individuals were assigned to the aerobic exercise or Nautilus study groups (according to individual preference for the type of exercise being done), with 44 entering the Nautilus group and 38 entering in the aerobic group. Baseline demographic data on the two groups is provided in Table 1. All individuals in the study were instructed on their prescribed exercises and were given log sheets to record the exercises done, with individual notation for each session including time of session, weight lifted, repetitions and weekly frequency of exercise sessions. Baseline bone density determinations were obtained on 76 subjects and 6 month determinations on 43 subjects. Thirty subjects completed 12 month determinations, with 15 individuals in each group. Six subjects did not complete bone densities and were lost early in the study. Exercise logs were reviewed at the three month interval visits. Also an assessment of calcium intake was completed at these visits and compliance with dietary and supplemental calcium recommendations noted.

An additional parameter was added to obtain bioelectric impedance testing of body fat content on all individuals. This addition was approved through appropriate channels and the measurements were obtained after the participants had been properly counseled and signed a separate consent form.

Reasons for dropouts during the study include: pregnancy (2), medical problems (7), retirement from the Army (3), movement to new assignment (14), lack of time (19), temporary duty away (1).

Delays in the protocol approval process resulted in a six month delay in starting this study and therefore an application for an extension of the study period was approved.

Changes in bone density were calculated using paired t-tests for measurements at zero and six months and zero and twelve months. Statistically significant increases in bone density were found in both groups at all three sites. See Table 2.

The groups were then compared with a z-test for means to compare percent changes in bone density. See Table 3.

Conclusions

Thirty premenopausal women completed a one year trial comparing aerobic to resistance-exercise for influence on bone density. Both groups showed significant increases in bone density compared to baseline at all 3 sites after both 6 months and 12 months of exercise. The two groups were compared by assessing percent changes in bone density from a baseline at six and twelve months. At six months bone density had increased significantly more at L2-4 in the resistance exercise group but more at the mid-radius in the aerobic group. At twelve months the resistance group showed higher bone densities at the femoral neck and mid-radius but the two groups were not significantly different at L2-4. Site specific analysis of resistance exercises may further delineate the benefits of specific resistance exercises.

Our data suggest that both aerobic and resistance exercises improve bone density in premenopausal women and further, that a moderate program of resistance exercise which emphasizes the hip girdle and arm regions has a greater effect at the mid-radius and femoral neck than does aerobic exercise. Recommending resistance exercises to premenopausal women, by increasing peak premenopausal bone mass, may afford increased protection against hip and wrist fractures in the postmenopausal years.

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EXERCISE STUDY

TABLE 1 DEMOGRAPHIC DATA

AEROBIC (A) NAUTILUS (N)

	Mean	Range	SE	n
Age (A)	31.6	21-40	0.92	38
(N)	31.8	19-40	0.75	44
Height (A)	64.7	56.8-69.8	0.41	38
(N)	65.3	60.5-74.3	0.39	44
Weight (A)	144.1	112-236	4.1	38
(N)	143.3	100-183	3.15	44
% body fat (A)	28.1	14-45	1.2	37
(N)	27.1	15-40	1.1	42
Scapular skin fold (A)	16.2		0.98	38
(N)	14.3		0.65	44
Ca intake (A)	835	173-2521	98.7	38
mg/d (N)	780	144-2161	66.2	44
Bone density mg/cm2				
L2-4 (A)	1.218	1.063-1.429	0.017	33
(N)	1.238	0.946-1.586	0.025	41
Fem. neck (A)	1.047	0.797-1.339	0.023	34
(N)	1.062	0.830-1.463	0.02	42
Mid-radius (A)	0.707	0.632-0.870	0.0086	34
(N)	0.71	0.606-0.824	0.0073	42
	Caucasian	Black	Hispanic	Other
Race % (A)	65.8	15.8	10.5	7.9
(N)	89.5	15.8	7.9	2.6

EXERCISE STUDY

TABLE 2 BONE MINERAL DENSITIES

AEROBIC (n=22)	Initial	6 Months	p
L2-4	1.223	1.235	0.06
Fem. neck	1.047	1.099	<0.001
Mid-radius	0.709	0.755	<0.001
NAUTILUS (n=21)			
L2-4	1.181	1.206	0.003
Fem. neck	1.028	1.082	<0. 001
Mid-radius	0.707	0.749	<0.001

AEROBIC (n=15)	Initial	12 Months	p
L2-4	1.232	1.254	0.003
Fem. neck	1.036	1.064	0.03
Mid-radius	0.714	0.762	<0.001
NAUTILUS (n=15)			
L2-4	1.184	1.21	0.04
Fem. neck	1.01	1.06	0.03
Mid-radius	0.705	0.76	<0.001

EXERCISE STUDY

TABLE 3 PERCENT CHANGE FROM BASELINE IN BONE DENSITIES

	Aerobic	Nautilus	p
6 MONTHS			
L2-4	0.9	1.93	<0.001
Fem. neck	5.16	5.46	0.16
Mid-radius	6.62	5.97	0.02
12 MONTHS			
L2-4	1.71	2.16	0.11
Fem. neck	2.76	5.23	<0.001
Mid-radius	7.03	7.71	0.03